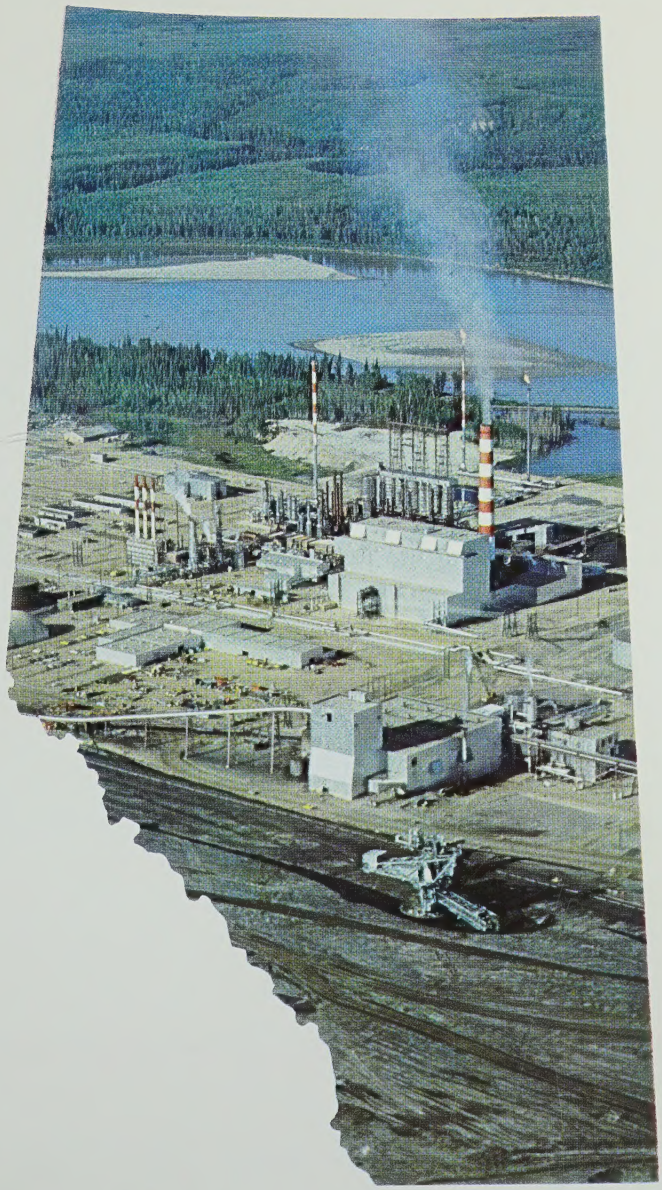
CONSERVATION IN ALBERTA

1967



OIL AND GAS CONSERVATION BOARD
603 SIXTH AVENUE SOUTH WEST - CALGARY, ALBERTA

PREFACE

"Conservation in Alberta, 1967" has been prepared by the Oil and Gas Conservation Board to acquaint members of the Legislative Assembly of Alberta and the public at large with the conservation of Alberta's oil and gas resources and with the role of the Board. The text has been written in a non-technical style without detailed statistics.

Included in the report are a discussion of the need for conservation, an outline of the responsibilities of the Board and a brief review of the reserves and production of oil and gas and their by-products. The enhanced recovery of crude oil and the conservation of solution gas are also discussed. This particular edition recognizes 1967 as a milestone year in the development of the Province's oil sands by featuring a special section entitled "Alberta Oil Sand Resources". A second feature section describes the Board's rock data library. The final section in the report briefly summarizes Board operations during 1967.

The detailed publication "Report of the Operations of the Oil and Gas Conservation Board" is not being published for general distribution this year but is available on request.

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COVER PICTURE: Our cover picture, courtesy of Sun Oil Company, is an aerial photograph of the mine face and plant complex of the oil sands development operation of Great Canadian Oil Sands Limited on the banks of the Athabasca River, twenty miles north of Fort McMurray in north-eastern Alberta.

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603 - 6 AVENUE SOUTH WEST, CALGARY 1, ALBERTA, CANADA

THE NEED FOR CONSERVATION

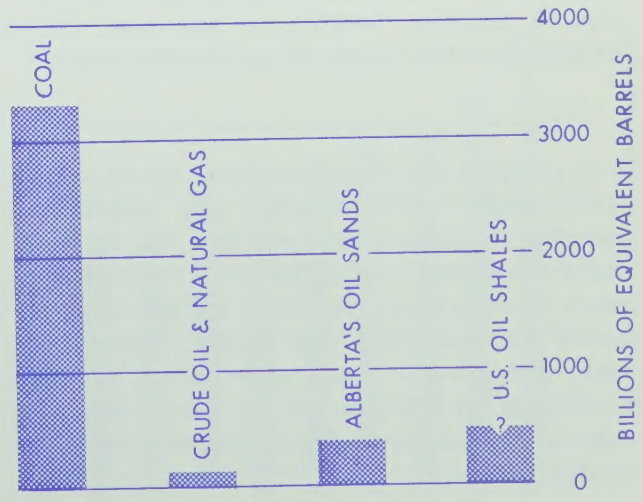
There is a direct and well founded relationship between the energy consumption of a country and its standard of living. North America's high living standard is matched by its rate of consumption of energy, which each year establishes new record levels. This growth is expected to continue at an annual rate of at least 4.5 per cent. Growth at even 4.5 per cent annually means that energy use will about double in the next 15 years. It seems certain to quadruple by the year 2000. Our principal sources of energy — coal, hydro, oil, natural gas and more recently, nuclear power, will each be heavily burdened to meet the demands to be made on them. Crude oil resources will likely be particularly hard pressed because since about 1950 it has come to be the largest single source of energy for North American homes and industry. It, together with natural gas, now supplies about three quarters of our energy needs, and prospects are that it will continue to do so.

With our whole future dependent upon our ability to meet growing energy demand, it becomes increasingly important that we make the most efficient possible use of what energy resources we have. Crude oil is perhaps the most important and since it is non-renewable in nature we must minimize its waste and use only the most efficient recovery process while producing each pool. Natural gas is another depleting energy resource, and it also presents a challenging conservation problem, since an important part of our gas reserves is produced unavoidably with crude oil. Because of its convenience and flexibility, natural gas will play an important, although selective, part in our energy supply program.

Alberta's position in the North American energy market is most favourable. It is now generally accepted that the doubling and redoubling of energy needs in the next thirty years or so will bring with it continental shortages in oil resources. In this environment Alberta's conventional oil industry, which is now producing at something less than one-half its productive potential, will clearly play an important role. The growth in energy requirements however, is of such magnitude that conventional reserves cannot be expected to meet the growing demand and a second generation of oil development is expected from Alberta's extensive oil sands resources. These deposits are now on the threshold of industrial exploitation with one commercial plant already in operation and a dozen or more experimental extractive tests in progress. The oil sands thus represent an energy backstop for Alberta and have excellent prospects in the next decade and beyond of playing a major role in satisfying North America's energy needs. Conservation will be well served if, without seriously disturbing the development of our conventional oil and gas resources, the next few years can be used to develop the necessary technology so that at the appropriate time rapid and large scale development of the oil sands can occur without waste.

The growing energy demand has also renewed interest in coal liquefaction and gasification processes. Currently, the oil industry in the United States is investing substantial sums

FOSSIL FUEL RESERVES OF NORTH AMERICA



of money in experiments and research towards this goal. Should commercial exploitation prove feasible, the extensive coal resources of the North American continent would play a role in assisting to meet the increasing shortage in conventional oil and gas reserves. From these developments a third generation of energy resource exploitation may evolve. With its abundant coal reserves, Alberta is favourably situated to participate in this area as well.

RESPONSIBILITIES OF THE BOARD

The Oil and Gas Conservation Board was established by the Alberta Legislature in 1938. Its basic purpose, as set forth in The Oil and Gas Conservation Act, is to ensure the conservation of the Province's oil and gas resources. More particularly, it is responsible for eliminating any practice which reduces the economically recoverable quantity of oil or gas, for ensuring safe and efficient drilling and production methods, and for providing an opportunity for each owner in an oil or gas pool to recover his fair share of the production from that pool.

To discharge its responsibilities effectively, the Board must see that in the light of sound engineering and economic principles, oil and gas field operations are so conducted that wells are properly located, spaced, drilled, equipped and produced, so that the recovery of oil or gas from the pool is not lessened and reservoir energy is not improperly dissipated. The Board must also make certain that enhanced recovery techniques are used where suitable and that waste of gas is minimized.

In carrying out these functions the Board, in co-operation with industry, has established specific regulations and policies. The Act provides the Board with authority to require operators to undertake operations necessary to improve conservation. The Board, through its staff, maintains a close surveillance of each producing oil and gas field to ensure that producing operations will provide maximum recovery.

Protection of the interests of owners in oil and gas pools is provided under the Act and Regulations. This is achieved largely by well spacing regulations and by the regulation of production under uniform rules. In exceptional cases further measures, such as common carrier or common purchaser orders, are available.

The Board co-operates with other Government departments and industry to ensure that field producing practices do not lead to the destruction or contamination of other natural resources.

The Board is also responsible under The Gas Resources Preservation Act, 1956, for seeing to the effective utilization of the Province's gas resources. Applications for removal of gas or propane from Alberta are evaluated having regard to the present and future needs of the people within the Province, and permits are granted only for quantities surplus to these needs.

Since 1958, some special responsibilities in the old Turner Valley Field have been given to the Board by The Turner Valley Unit Operations Act. Because of the wide diversity of ownership in the Field, and to expedite plans for improving recovery from it, the Board was authorized to combine diverse holdings into a single unit operation if one or more owners requested it. Five units comprising the whole of the Turner Valley Rundle Pool have since been established.

CRUDE OIL

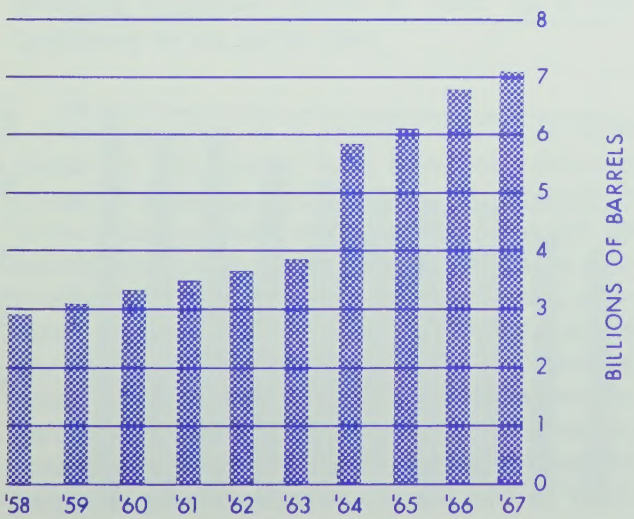
The Board estimates that Alberta's initial recoverable reserves of conventional crude oil grew by 598 million barrels in 1967. Since production amounted to some 230 million barrels during the year, a net increase of 368 million barrels occurred in Alberta's remaining recoverable reserves of conventional crude oil, which totalled 7,130 million barrels at the year's end.

The 1967 increase in Alberta's initial recoverable reserves of conventional crude oil was surpassed in only two years, 1964 and 1966, during the last decade. An exceptional increase occurred in 1964, which resulted mainly from a reappraisal and extension of enhanced recovery schemes in numerous pools. In 1966, large additional reserves were recognized in Rainbow Lake and Zama Lake in the northwestern corner of the Province. The latter areas made further substantial contributions to reserve growth in 1967.

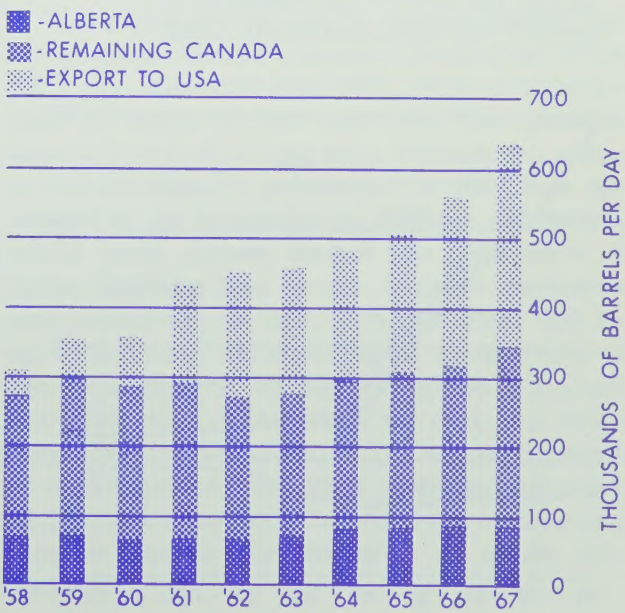
Production of conventional crude oil in Alberta averaged 631,000 barrels per day in 1967. In addition, the Great Canadian Oil Sands Limited plant which commenced operations in August, supplied modest amounts of synthetic crude oil over the last five months of the year. As compared to 1966, the demand for Alberta's crude oil was some 14 per cent higher, whereas the total demand for Western Canadian crude oil was only 10 per cent higher. Thus, during 1967 Alberta increased its share of the total market for Western Canadian Oil.

Alberta's export markets in the United States provided by far the strongest stimulus to demand in 1967. Exports of Alberta crude oil to United States markets were some 55,000 barrels per day higher than in 1966, an increase of 23 per cent. In part, this reflects temporary increases in exports to the U.S. West Coast as a result of the disruption of Middle East supplies following the Arab-Israeli war. However, a substantial increase, largely unrelated to the crisis, was recorded in oil exports to the U.S. Mid-

ALBERTA REMAINING CRUDE OIL RESERVES



ALBERTA CRUDE OIL DELIVERIES



West. The resultant growth in the eastward movement of Alberta oil placed severe strains on Canada's pipe line network during 1967. The limiting effects of capacity will be alleviated by pipe line expansion programmes scheduled for completion in 1968.

Alberta's remaining recoverable conventional crude oil reserves at the end of 1967 were sufficient to sustain production at the 1967 rate for a 31 year period. This represents a small reduction over 1966 and the two previous years, when "years of supply" remained stable at 33 years. The life of reserves in Alberta, measured in this manner, is considerably greater than in Canada as a whole and the United States, for which the corresponding numbers are 24 years and 10 years, respectively.

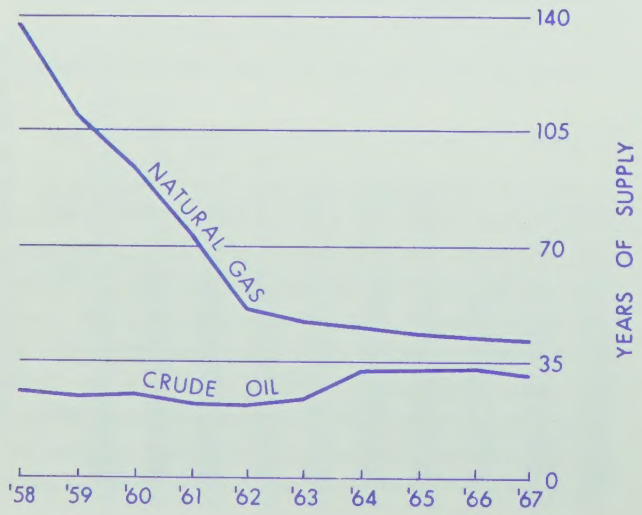
NATURAL GAS

The Province's initial reserves of natural gas increased by some 2.6 trillion cubic feet during 1967, an improvement on the growth of only 1.4 trillion cubic feet which occurred in 1966. Approximately one trillion cubic feet of natural gas were produced during 1967, with the result that the year-end remaining reserves of natural gas of 39.7 trillion cubic feet were 1.6 trillion greater than at the end of 1966.

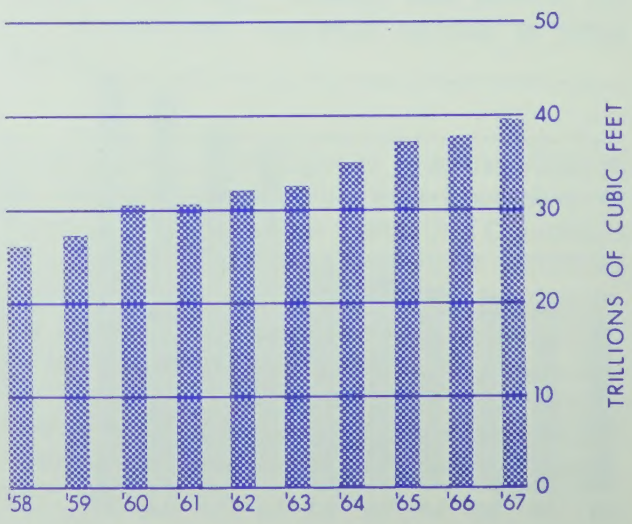
Over the last decade an increasing share of Alberta's natural gas production has been marketed in other Canadian provinces and the United States. However, in 1967 and the two previous years, the share of production going to these areas has remained remarkably constant. Requirements in the remainder of Canada and in the United States now account for some 80 per cent of Alberta's production, with a roughly even division between these two markets.

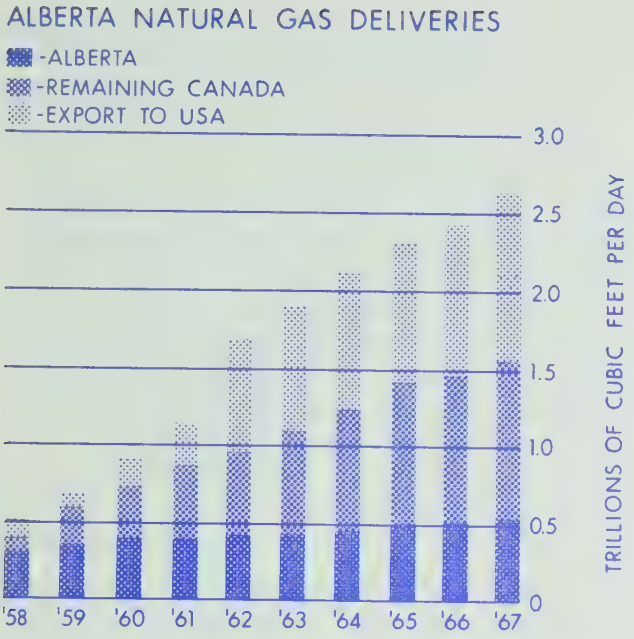
As with oil, the remaining reserves of gas may be appraised in terms of the number of years over which they can supply current market requirements. In 1967, the Board's estimate of remaining reserves indicated a 41 year supply. A continual decline is evident in this measure of Alberta's reserve life over the last ten years, reflecting the impact of new and rapidly developing markets especially in Eastern

YEARS OF SUPPLY OF ALBERTA CRUDE OIL AND NATURAL GAS



ALBERTA REMAINING NATURAL GAS RESERVES





Canada and the United States. Alberta's years of supply position is roughly comparable to that of Canada as a whole, but remains highly favourable in relation to the United States, where gas reserves are equivalent to only 16 years of supply.

NATURAL GAS LIQUIDS

The term natural gas liquids embraces three products — pentanes plus, propane and butanes — which are produced in association with crude oil and natural gas. Production of these products expanded rapidly in 1967, as it has continued to do since 1961.

Pentanes plus is a product similar to light crude oil and, hence, both pentanes plus and crude oil supply a similar market. An indication of the balance between the two is provided by considering pentanes plus production as a proportion of crude oil production. In 1966, pentanes plus production averaged 77,000 barrels per day and was equivalent to 14 per cent of crude oil production. In 1967, this proportion had fallen slightly to 13 per cent, despite an increase of 4,000 barrels per day in the level of pentanes plus production. At the end of 1967, remaining reserves of pentanes plus were over 675 million barrels, some 60 million barrels greater than at the previous year end. In terms of 1967 production rates, reserves were equivalent to 23 years of supply.

Production of propane and butanes has been absorbed to an increasing extent by markets outside Alberta. These markets now account for roughly 75 per cent of the total deliveries of Alberta's propane and butanes. In addition to markets for both products in other areas of Canada and the United States, an important new market has been developed for Alberta's propane in Japan during the last two years. At the end of 1967, the estimated reserves of propane and butanes totalled some 680 million barrels, or the equivalent of about 32 years of supply at current rates of production.

SULPHUR

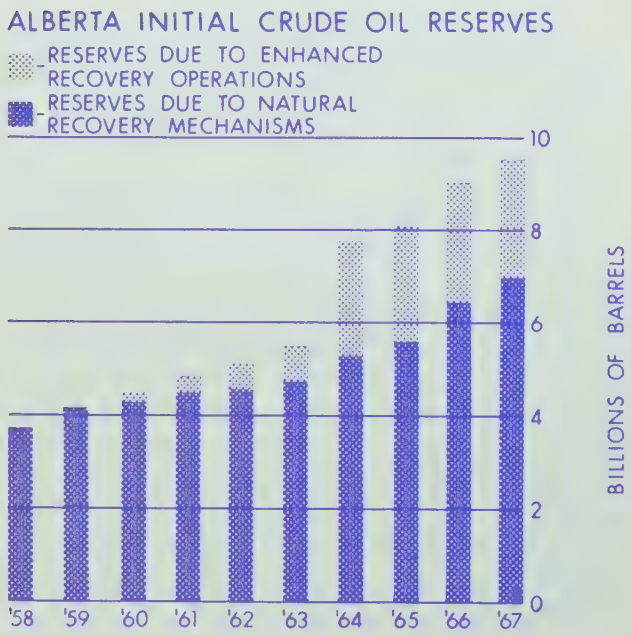
Sulphur, like natural gas liquids, is an important by-product in the converting of raw gas to a commercially saleable form. In recent years there has been a rapid rise in the world price of sulphur which has changed the sulphur content of raw gas from a nuisance to a valuable source of income.

The exceptionally strong growth which has occurred in Alberta's sulphur production since 1958 was extended into 1967, when production rose by some 23 per cent over the previous year to 2.12 million long tons. Virtually the whole of the increase in production in 1967 was absorbed by an expansion in offshore shipments, which were almost double the 1966 level. A better balance was struck between deliveries and production in 1967, with the result that inventories were stabilized after three years of continual decline. At the end of 1967, the sulphur reserves of Alberta's oil and gas fields amounted to 117 million long tons, an increase of seven million over 1966 and the equivalent of 55 years of supply. This does not include any sulphur reserve attributable to oil sands processing.

ENHANCED RECOVERY OF CRUDE OIL

Man's ability to recover oil from different kinds of oil pools varies over a surprisingly wide range. It depends, among many things, on the character of the oil and the sort of rock it occurs in, plus depth of burial, and the amount of energy naturally present to bring it to the producing wells. Recovery of oil by use of natural forces only, called primary recovery, is often severely limited by low pressure energy or by unfavourable flow channel properties. In many reservoirs it is possible to improve the recovery performance by artificially assisting or altering the natural underground forces. Such an operation is an enhanced recovery project.

It is the Board's purpose to see that enhanced recovery operations are undertaken in all pools where it is feasible. Each plan for enhanced recovery operations must be agreed to by the Board before being instituted. It is reviewed for recovery efficiency, technical adequacy, and the impact on the rights of other owners. The type of scheme undertaken must be one which will recover the maximum amount of oil and gas, bearing in mind the economics of the operation.



Usually an enhanced recovery operation is one in which either water or gas is injected into the oil producing zone to assist in propelling the oil to the well bore. Some examples of enhanced recovery schemes are discussed below. Without recovery enhancement, the average recovery of the oil so far found in Alberta would be only 23 per cent. With recovery enhancement, this recovery is now expected to be at least 32 per cent, a gain of over 2.5 billion barrels.

Two pools of interest which have been subjected for some time to horizontal displacement by water are Joffre Viking and Wainwright Mannville. Waterflooding of the Joffre pool is nearly complete, and the total oil recovery will be about 33 million barrels instead of the 13 million barrels expected from primary recovery. A similar improvement in per cent recovery is expected from the old Wainwright Field, where the Board in 1962 initially compelled pressure maintenance, now willingly continued and expanded by the well owners.

Among many enhanced recovery projects which were started in 1967, of special significance were those at the oil fields of Ante Creek near Valleyview, Buffalo Lake in the Stettler area, and Taber South just east of Lethbridge. Each of these projects is the first of its kind in Alberta. The Ante Creek miscible flood uses lateral displacement of oil by injected gas and water—not unusual in itself. In the conventional way, the gas produced with the oil is pumped into the formation, followed at infrequent intervals by large batches of fresh water. However, the scheme becomes unique when, at the high pressure and temperature existing in the reservoir, the gas injected becomes miscible (soluble) with the oil, and as a result sweeps the oil from the rock pores much more efficiently than in ordinary gas or water floods. The water is added to improve the distribution of the injected gas in the rock strata and to reduce the

volume of gas which is required. An estimated 60 per cent of the original oil will be recovered, an impressive increase over the 16 per cent anticipated by natural recovery.

At the dome-shaped Buffalo Lake pool, oil is to be displaced downwards and drained by well bores open near the base of the pay zone. Displacement will be by injection at the pool crest of inert gas produced by an engine-compressor which compresses its own exhaust gases. Approximately eight volumes of inert gas are produced from one volume of natural gas fuel. After most of the oil has been produced, the artificial inert gas cap will be blown off and the strong natural water drive from below will gather the remaining recoverable oil into the pool apex and so reduce terminal losses. The oil left behind in the rock pores will be much reduced by this special technique and a substantial improvement in recovery is expected.

The long, narrow Taber South pool contains heavy crude oil. Its enhanced recovery scheme involves the piston-like displacement of oil along the length of the pool by water which has been thickened by the addition of chemicals to prevent bypassing of the viscous oil by the water. While still somewhat experimental, a four-fold increase in oil recovery is expected from this pool.

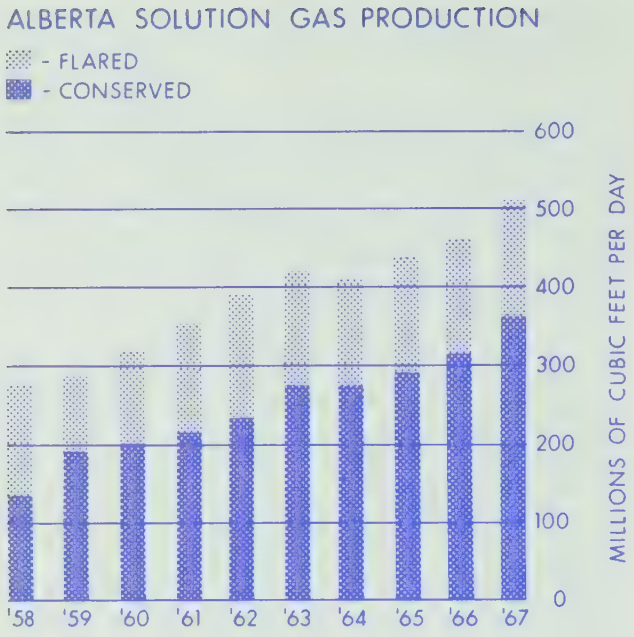
One of the most critical factors in any oil recovery process is the viscosity of the oil. If the native oil is highly viscous (of a thick consistency), primary recovery may be only a few per cent or even nil. The Province's "oil sands" deposits contain a form of oil which is so viscous that under natural conditions essentially no flow occurs into wells drilled to the deposits.

Some parts of the famous Athabasca oil sands are sufficiently close to the surface that the sands can be strip mined and the bitumen can then be separated from the solids in an extraction plant. Overall recoveries from such operations can be expected to be of the order of 75 per cent in terms of crude bitumen, or 45 per cent in terms of a light synthetic crude oil. All of the other oil sands deposits and the major part of the Athabasca deposit are not amenable to strip mining, and experiments are being conducted by owners to develop methods of recovering the oil through wells. One way to do so is by reducing the oil's viscosity by injecting a hot fluid such as steam, or by burning some of the oil in the formation. Variants of these thermal methods have been tested in experimental field operations in our oil sands and heavy oil reservoirs, but details have not been published in most instances. Twelve experimental oil recovery projects were operating at the end of 1967, most of them in the Cold Lake area.

CONSERVATION OF SOLUTION GAS

Some 185 billion cubic feet of solution gas was produced unavoidably with oil in Alberta in 1967, representing approximately 15 per cent of the total gas production of the Province.

Approximately 72 per cent of the solution gas produced during the year in the Province was conserved. This compares with about 47 per cent in 1958 and 68 per cent in 1966. The 1958 percentage is quite low and reflects the flaring of large volumes of gas produced during the development period of the Pembina field prior to the completion of gathering and processing facilities. By 1959, the Pembina conservation system had become operative and the percentage of solution gas conserved increased to 65 per cent, only to decline again temporarily due to the rapid development of the Swan Hills area. The increase during 1967 is due to new conservation schemes in the Medicine River, Ferrier and Rainbow Fields. Also,



much of the increase in oil production during the year occurred in the larger fields where facilities capable of conserving substantially all of the solution gas produced had already been installed.

Solution gas supplies over one-third of Alberta's present gas requirements, although it makes up only one-tenth of the Province's remaining gas reserves of 39.7 trillion cubic feet. One of the Province's major gas utilities, Northwestern Utilities Limited, obtains some 55 per cent of its total gas supply from solution gas, with the Pembina and Swan Hills areas supplying the main portion.

Of the solution gas conserved in 1967, two-thirds was gathered and processed for sale as marketable gas, as liquid products, or as sulphur. The other third was injected into underground natural reservoirs, either for storage or to increase the recovery of crude oil. About one-quarter of the propane and butanes produced in Alberta in 1967 resulted from the processing of solution gas.

The Board is responsible for ensuring that solution gas is not wasted if it can be conserved economically. The Board staff reviews regularly all producing oil pools in which the solution gas produced is not conserved in order to determine whether conservation of the gas is feasible. When it does appear feasible, the Board meets with the operators to encourage them to undertake operations for the gathering of the solution gas and has authority to restrict or prohibit the production of oil should such operations not be undertaken.

In the larger oil fields, the volume of solution gas available for conservation depends upon the production of oil, which is influenced significantly by market demand. Since the demand for oil varies from month to month and from year to year, the design of facilities capable of handling essentially all of the gas produced can be quite difficult. The capacity of the gas gathering system and plant is based upon an estimate of the volumes of gas that will be available some years into the future. Because of the innate difficulty in a prediction of this type, some plants have turned out to be overdesigned, while others have proved to be of insufficient size.

The Judy Creek gas conservation scheme, involving gas produced from the Judy Creek, Swan Hills South, and Virginia Hills oil fields, is an example of an undersized scheme. The extensive growth of the area and the rapid increase in demand for oil from the fields resulted in more gas becoming available considerably sooner than was estimated at the time of design. To avoid flaring the substantial quantities of excess gas involved, the production of oil from the pools was reduced by an average of some 4,000 barrels per day so that the solution gas produced could be conserved by the facilities available. Recently the plant has been expanded so that all the gas now produced can be conserved. The three million barrels of under-production accumulated during the period of insufficient capacity will be made up as plant capacity in excess of current allowables becomes available.

In some fields the gas associated with the production of oil is expected to decrease rapidly from the level being experienced when designing gas conservation facilities. For eco-

nomic reasons, these facilities may be designed not for the present level of production, but for some lower level expected to be fully utilized over a long period. In this circumstance, some gas will be flared during the first few years. The Board toletrates such flaring provided the quantities are small and there are no alternative economic remedies.

ALBERTA'S OIL SANDS RESOURCES

An important milestone in the history of Alberta's famous oil or "tar" sands was reached in September, 1967, with the formal opening near Fort McMurray of the first commercial scale oil recovery project. Because of the actual and potential impact of this event on the district and the Province, it is fitting that we focus attention on the oil sands at this time.

The recorded history of the Athabasca sands dates back to 1778, when the oily outcrops along the Athabasca river system were first seen by traders and explorers. During the period from 1875 to 1918, many field surveys were conducted by Canadian government geologists who confirmed the suspected vast extent of the deposit. Extensive field work continued after this time, with that of S. C. Ells being particularly noteworthy. The period 1918 to 1950 saw federal, provincial and private efforts to extract oil and to delineate specific areas suitable for development. Especially significant was the work of the federal government's Mines Branch, the International Bitumen Co., Abasand Oils Ltd. and Boyle Brothers Drilling Co. In the late 1940's, Dr. K. A. Clark of the Alberta Research Council and the Alberta Government climaxed years of effort on the hot water separation process by successfully operating a pilot plant at Bitumount. In the 1950's oil company funds began to pour into research on extraction techniques, and on underground (in situ) processes which do not require mining of the sands. This same work continues today.

The 45,000 barrel per day project of Great Canadian Oil Sands Limited was constructed in 1964 to 1967 under the guidance of the parent company, Sun Oil Company, and the prime contractor, Canadian Bechtel Limited. The commencement of production in August is attributable to the trail-breaking efforts of these companies and to the skills of their personnel.

The $230 million Great Canadian project is more than a single plant in which raw materials are converted to finished product. It is an integrated sequence of mining, extraction, upgrading, and transportation facilities which provides almost all of its own utilities. The initial step in the sequence is the removal of overburden and mining of the 130 foot thick oil sands. The oil sand is mined by huge electric digging wheels, then conveyed into the extraction plant at the rate of one ton per second. The crude bitumen is recovered as a wet froth from the separation vessels of the modified hot water process and is purified by centrifuging. The clean sand tailings, representing all but 12 per cent of the material entering the plant, are discharged to a diked area and will eventually be used to refill the mined area.

The heavy sulphurous crude bitumen is "cracked" in a refinery-like process section. The products from the cracking step are gas and coke, which are used as fuels, and liquid hydrocarbons, which are further refined to make the sulphur-free synthetic crude oil product. By-product sulphur is recovered from the gas streams. The oil is transported by pipe line to Edmonton, from where it is shipped to Eastern refineries.

At the end of 1967, the new plant was producing modest amounts of oil from the sands,

but was having the sort of start-up difficulties often associated with a new operation.

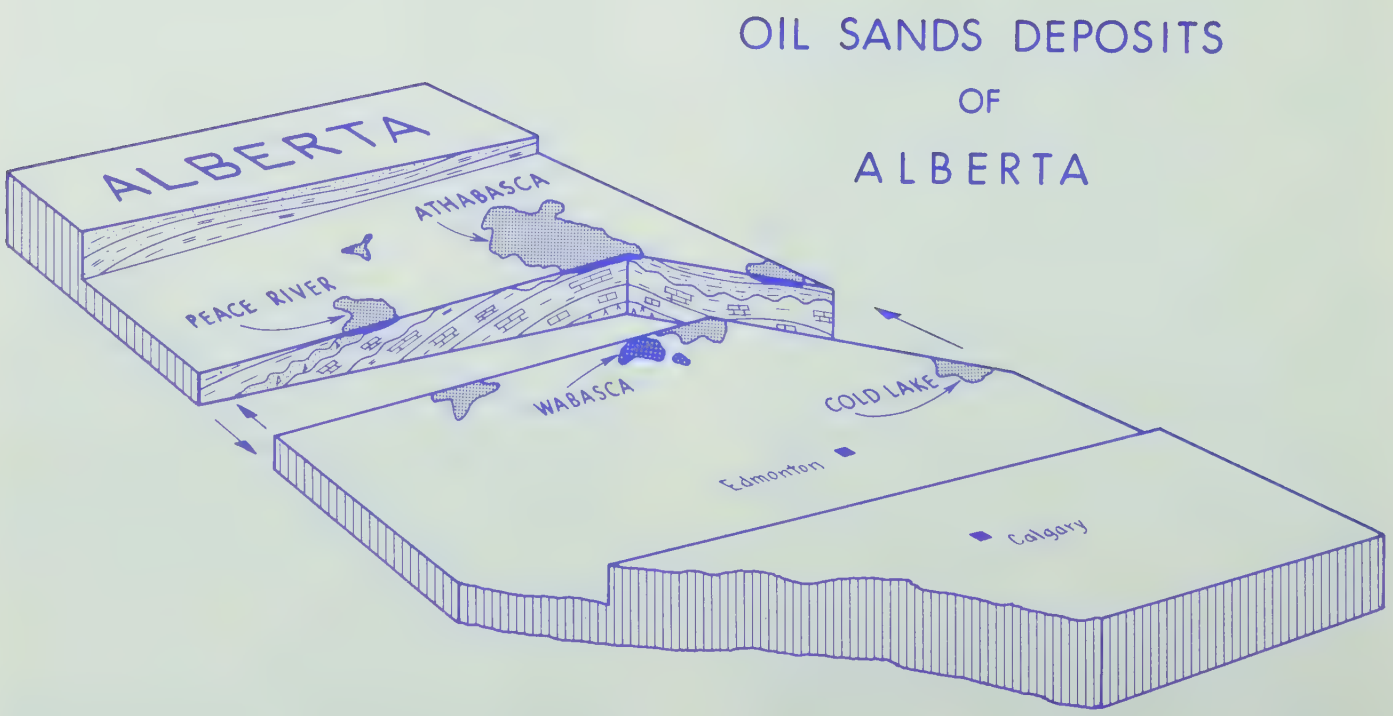
During its 30 plus years of life, the project will use up the crude bitumen reserves in an area of about six square miles, representing about 0.13 per cent of the reserves in the Athabasca deposit.

DESCRIPTION AND RESERVES OF THE OIL SANDS DEPOSITS IN ALBERTA

The oil sands of Alberta are defined as those sands containing crude bitumen. Crude bitumen is a viscous hydrocarbon mixture that in its natural state is not recoverable at commercial rates through a well.

The accompanying illustration shows the geographic position and approximate areal extent of each of the main oil sands deposits of Alberta.

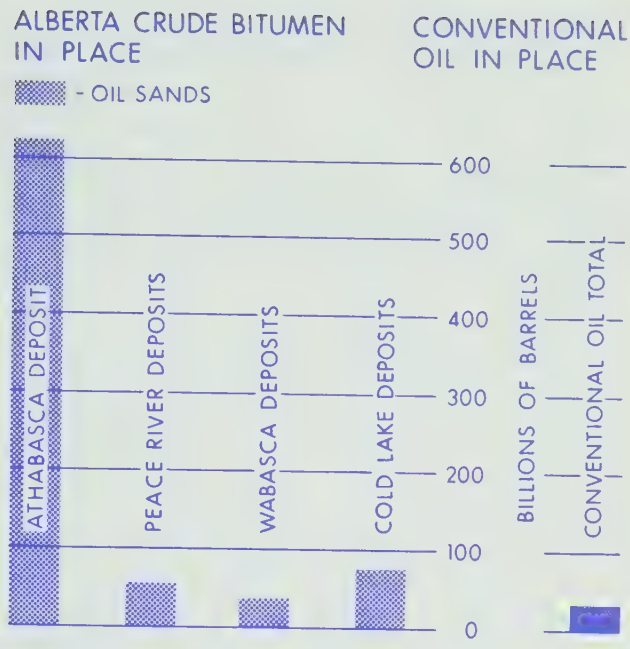
The Athabasca deposit is the largest of the oil sands deposits, covering an area of about six million acres and ranging in thickness from 75 to 300 feet. It occurs mainly in the McMurray Formation and contains crude bitumen having an average gravity of about 10 degrees API. This deposit is locally exposed at the surface in the vicinity of the Athabasca River. Elsewhere, it is covered by overburden ranging up to 2,000 feet in thickness. The volume of crude bitumen in place has been estimated by the Board to be in excess of 600 billion barrels, from which over 300 billion barrels of synthetic crude oil may eventually be recovered under favourable economic conditions. Most of the bitumen is deeply buried and, therefore, would likely be recovered through wells by in situ processes. A lesser portion, perhaps 10 to 20 per cent, is covered by relatively thin overburden and is potentially accessible to surface mining recovery methods.



The other significant deposits in northern Alberta are known as the Peace River and Wabasca deposits. Both contain a bitumen that is similar to the bitumen in the Athabasca deposit and both will likely be considered for in-situ recovery as they are relatively deeply buried. The Peace River deposit occurs in the Bluesky-Gething Formation of Lower Cretaceous age and contains approximately 50 billion barrels of crude bitumen in place. The Wabasca and associated deposits are located southwest of the Athabasca deposit, occur in the Grand Rapids Formation of Lower Cretaceous age and contains approximately 30 billion barrels of crude bitumen in place. These deposits have not been fully delineated by drilling.

The Cold Lake deposits occur south and slightly east of the Athabasca deposit. The bitumen is contained in several sand units of the Mannville Group and the gravity of the bitumen in the area varies from 10 to 15 degrees API. There is some possibility that part of the area may have heavy oil deposits similar to the conventional heavy crude oil pools in the Lloydminster area and hence may not be strictly classifiable as oil sands. The Cold Lake deposits have not been well delineated but they are believed to contain at least 75 billion barrels of crude bitumen in place. They are covered by 900 to 1,600 feet of overburden and, therefore, would not likely be suitable for mining operations.

The bar graph shows the volumes of crude bitumen in place in the several oil sands deposits. Included for comparison are the total conventional volumes of crude oil in place discovered to date in Alberta. Only portions of the volumes shown by the bar graph are capable of being recovered.



OIL SANDS DEVELOPMENT POLICY

The policy of the Alberta government towards development of the oil sands was formalized in October, 1962, and revised to a modest extent in February, 1968. The general aim of the policy is to provide for the orderly development of the oil sands in such a manner as to supplement but not displace production from the conventional crude oil industry. The Oil and Gas Conservation Board is directed by the government to administer the policy. This includes the holding of a public hearing in connection with each application for a development permit or "approval", and making a recommendation to the government.

In its consideration of an application, the Board hears evidence from the applicant and any interested persons on the subjects of resource conservation, the prevention of pollution, the technical and economic feasibility of the proposal, and the impact of it on the market for conventionally produced oil. Under the government's development policy, hydrocarbon products from oil sands may be produced without market restrictions if the products are destined for markets not now, or likely to be, served by Alberta's conventional oil. Until such time as the "reserves life index" (remaining reserves divided by the current producing rate) of conventional crude oil is reduced to a level suggesting the need for supplementary supplies, oil sands production for markets within reach of conventional oil is limited to 150,000 barrels per day, including the 45,000 barrels per day now authorized to Great Canadian Oil

Sands Limited. In order to gain a share of the 150,000 barrels per day limit, a company must provide a new market and share this market equally between its oil sand operation and the conventional industry in Alberta. The 150,000 barrels per day limit is subject to review respecting its applicability to the period after 1973.

In addition to hearing applications for commercial oil sand development schemes, the Board considers applications for experimental oil recovery schemes and performs a continuing surveillance of field and plant operations in oil sand areas, and collects and distributes statistical and technical data relating to oil sands.

ALBERTA'S LIBRARY OF ROCK DATA

The drilling of 11,800 dry holes and 17,200 oil and gas wells in Alberta has produced very large amounts of data in the form of well logs, drill cuttings, and cores. The Oil and Gas Conservation Regulations require owners of wells drilled for oil and gas to submit this material to the Oil and Gas Conservation Board, where they are stored in a rock data library and are accessible for examination. The library serves industry from two separate locations; the Board's main office in downtown Calgary, where well logs are kept, and the Core Storage Center in north-west Calgary, where drill cuttings and core are stored.

The technical knowledge obtained from well logs, drill cuttings, and cores is vital to the success of the oil and gas industry, particularly in conducting research, in undertaking exploration and development, and in effecting conservation. Therefore, it is essential that these invaluable data be permanently stored and made available for current and future studies.

A description of well logs, drill cuttings and cores and brief reference to their purpose is given in the following paragraphs.

WELL LOGS

A typical well log is a paper record, nine inches wide and several feet long, that shows certain properties of the rocks and fluids in the vicinity of the bore hole of a drilled well. Each record contains one or more continuous wavy lines that indicate the rock or fluid properties at varying depths. The values shown by each line can be converted into useful information by the use of log interpretation charts and special calculations.

Many kinds of measurements of rock and fluid properties may be made. The selection of logs to be run at a well is dependent on the specific information that is required and the conditions present at the well.

Logs are obtained by running a specially designed mechanical tool in the well bore. As this tool is retrieved from the well bore, measurements are electronically recorded on film. Final paper prints are then made from the film negatives.

Well logs may be used for many purposes, some of which are as follows: (1) to determine subsurface conditions by correlating marker beds, (2) to determine fluid interfaces, saturations, and rock types, (3) to measure hole size for cementing casing, and (4) to obtain acoustic information which is useful in both reservoir evaluation and seismic work.

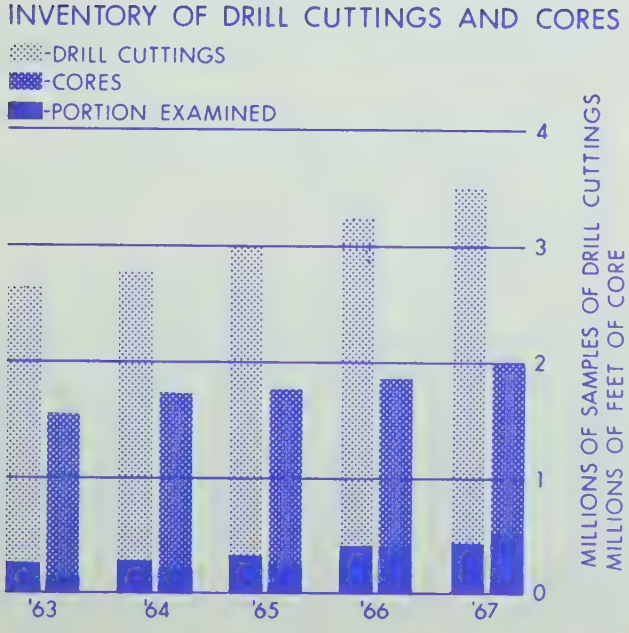
Although the Board is not the sole custodian of well logs, copies of logs taken on Alberta

wells are filed at the Board's main office and are readily retrievable for examination. The Board's well log library contains some 75,000 separate records of various measurements made in wells in the Province.

DRILL CUTTINGS

Drill cuttings are small fragments of rock which have been chipped off by the drill bit and carried to the surface by the drilling mud. Typically, the rock fragment will be the size of a match head, or smaller. A sample of the cuttings weighing about eight ounces is normally collected during drilling operations from consecutive 10-foot sections of geologically important intervals in the well. Each sample is put into a labelled bag.

A geologist at the well site makes first use of the cuttings that have been collected. He examines them under a microscope to determine the type of rock that is being drilled and looks for porosity and staining. This information helps him to decide if any zones should be tested or cored. After drilling operations are completed, the cuttings are forwarded to the Core Storage Center for future studies.



At the Core Storage Center, the bags containing the cuttings are sorted into proper depth sequence. The cuttings are then run through a machine washing and drying process at an average rate of 180 samples per hour. About an ounce of the clean cutting is put into a labelled glass vial for storage. The accompanying bar graph shows that approximately 3,500,000 vials, representing almost one quarter of the total footage drilled in the Province to date, are stored in the library and are available for study. There are 28 public examination booths at the Center and during 1967 an average of 11 patrons used the facilities each working day. Approximately 450,000 vials are examined annually.

CORES

Cores are cylinderically shaped pieces of rock cut from underground rock formations when drilling a well. They usually have a diameter of slightly over three inches. A specially designed diamond studded bit is commonly used in the cutting operation, replacing the usual drilling bit. As the core is cut, it is forced into a core barrel and ordinarily is recovered from the barrel in about two inch to two foot long sections. The cores provide a larger sized sample of the zone of interest than do drill cuttings, hence are more reliable and useful, but more costly.

By measuring in a laboratory the physical properties and residual fluid saturations of a core, additional information that is useful in reservoir engineering is derived.

After a core has been examined, and in most cases analyzed, it is forwarded to the Core Storage Center by the owner. At the Center, it is permanently stored in cardboard boxes, each

box holding some five lineal feet. As shown in the bar graph, the current core inventory is over two million lineal feet and it is increasing at an approximate rate of 125,000 feet per year. The details of the inventory of core are recorded on a punchcard system that permits efficient retrieval from storage and sorting into geological categories.

Examination facilities include 18 examination tables that are serviced by electric fork-lift trucks equipped with a two-way radio system. Approximately 500,000 feet of core are examined annually. During 1967, an average of 13 patrons used the facilities each working day.

An additional service, not part of the normal operations, is core cutting. This service is provided at cost to any operator who desires to obtain a thin slab of his core. The cutting utilizes a large power operated diamond saw that can slab approximately 100 lineal feet of core per hour.

Alberta's rock data library is likely the largest of its kind in the world. It has been, and continues to be, a major undertaking to preserve valuable data for use in geo-scientific research. It is jointly financed by the oil industry and government, and is expected to produce substantial returns for present and future generations.

SUMMARY OF BOARD OPERATIONS — 1967

IMPORTANT ACTIVITIES IN 1967

The Rainbow and Zama Fields in north-western Alberta continued to develop rapidly, and at year end included 200 producing wells in 150 separate pools. The large number of small separate pools has resulted in very heavy demands on the technical staff of both industry and the Board to analyze each oil pool's characteristics and performance as rapidly as possible in order to determine the amount of oil in the pool, its rock and fluid characteristics, and the most efficient method of recovering its oil and gas. A second major oil pipe line to serve the area was under construction at year end.

Throughout the province a variety of new enhanced oil recovery projects were initiated during the year, including a high pressure miscible gas flood, a solvent bank, and injection of inert gas. Re-evaluation by the Board of a solvent flood scheme in the Pembina Cardium Pool culminated in a major Board report. (1)

The Board considered and approved two applications for permits to remove an additional 2.3 trillion cubic feet of gas from the Province. In reviewing the availability of gas to satisfy the proposed increased exports, the volume of gas in some 500 pools was determined. Production and pressure history of many pools was reviewed to assist in gas reserve determinations, and detailed studies of the deliverability of most of the larger gas pools were conducted to assess the applications for increased export of Alberta's gas.

Continuing efforts to improve gas conservation resulted in the issuance of orders requiring conservation of gas in three areas. Where gas plant capacities were not adequate to process all gas produced at high oil allowable rates, part of the oil production of some large pools was deferred until adequate plant capacity was available.

Conversion to the IBM System 360 of existing computer applications, including those in Production Accounting, was essentially completed during 1967. In addition, a general well data and core analysis computer storage and retrieval system was designed. By the year end, over 95 per cent of the data to be stored in this system had been converted to computer format, the programs necessary to edit the data and create the files had been written and test-

(1) OGCB REPORT 67-B REPORT AND DECISION ON REVIEW OF CERTAIN SOLVENT FLOOD OPERATIONS IN THE PEMBINA CARDIUM POOL. MAY, 1967.

ed, and the files were being developed. These will be completed during the first half of 1968.

The Board's continuing program to ensure that no soil or water pollution occurs from disposition of oil field water resulted in the return of 98 per cent of all salt water to subsurface formations. Special emphasis on inspection of drilling activity in the Rainbow and Zama Fields appeared to be successful, since no major blowouts occurred in this area, where well conditions indicated a high blowout hazard. The field staff also made special attempts to improve the accuracy of water measurement at gas wells, since the presence of water can have a serious effect on the recovery of gas from a pool.

In consultation with industry representatives, a major review of the Drilling and Production Regulations and several administrative policy matters was made during the year. New, simplified Conservation Regulations consolidating all necessary regulations and policy directives were issued in loose leaf format early in 1968. Future policy directives and amendments to the Regulations will be indexed and replacement pages issued. Significant changes were made in the oil well target area regulations to provide for a larger and central target area.

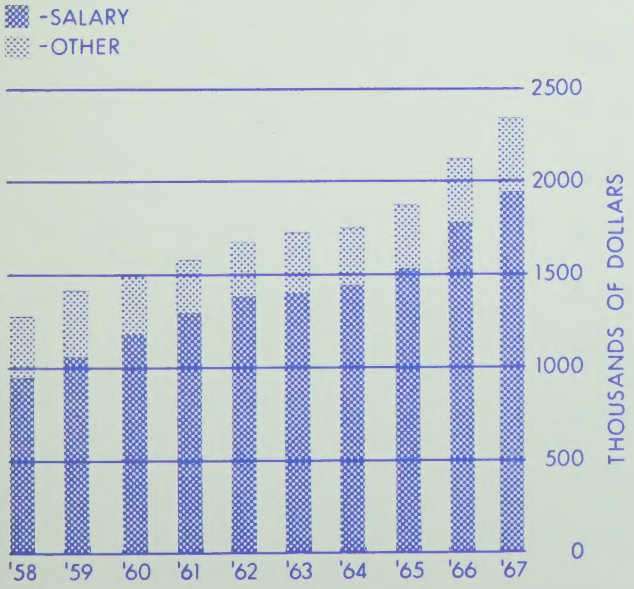
REVENUES AND EXPENDITURES

The revenues of the Board are provided by a direct grant to meet 40 per cent of net expenditures from the Government of the Province of Alberta, and the levy of a tax on oil and gas properties in the Province for the remainder. Since the government is taxed as the owner of Crown lands, the revenues are borne about equally by industry and government.

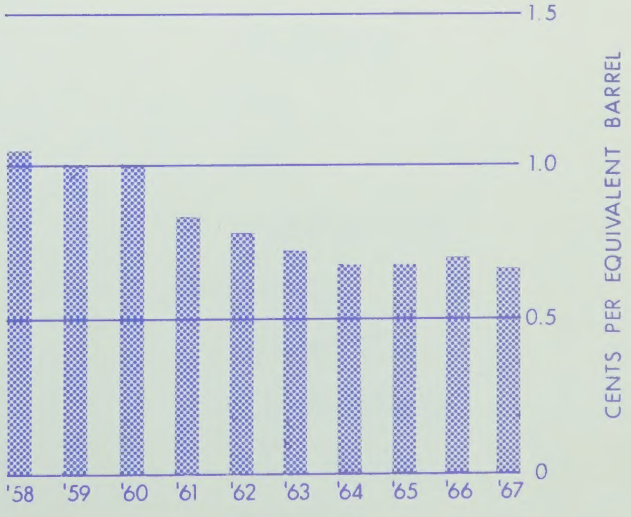
In 1967, revenues were raised to meet a net expenditure of 2.3 million dollars after the receipt of some $225,000 from licence revenue and the sale of information.

The accompanying graphs show: (1) the level of Board net expenditures over the past ten years and indicate the relationship of salary expenditure to the total expenditure after the deduction of miscellaneous revenue, and (2) the relationship of Board operations cost to production revenues in the Province by industry. This is done by reducing Board net expenditure to the number of cents per equivalent barrel* of crude oil production. During the last ten years this cost has been reduced from one cent to its present two-thirds of a cent.

BOARD NET EXPENDITURES



BOARD NET EXPENDITURE PER EQUIVALENT BARREL OF CRUDE OIL PRODUCTION



*EQUIVALENT BARREL = TOTAL INDUSTRY PRODUCTION REVENUE DIVIDED BY THE WEIGHED AVERAGE PRICE PER BARREL OF OIL.

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